January 24, 1934: The condition was worse, and fluid did not pass to the nose on syringing. Occasional recurrences of blockage had taken place.

May 21, 1934: A stereoscopic photograph was made at the Toronto General Hospital after injection of the sac with thorium dioxid.

The chronic course of the disease, with frequent relapses, caused considerable apprehension. The ophthalmologic department could not agree with the report from the radiologic department as to the site of the blockage, which is so clearly shown in the accompanying illustration.

LOCAL ANESTHESIA IN OPHTHALMOLOGY*

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FOREWORD

The aim of this article is to assemble and make easily available the more generally accepted methods of local anesthesia in ophthalmology. A few modifications that have been tried and found satisfactory are included.

HISTORY

Anesthesia has unquestionably been one of the great factors in the evolution of modern surgery, and has been, in a large measure, responsible for the tremendous advance that has been made in surgery during the past eighty-seven years, since its introduction. It is difficult to picture surgery without the aid of anesthesia, but this was true of it less than one hundred years ago. In spite of the fact that the desire to prevent pain during surgical operations dates back to antiquity, this aim was not realized until comparatively recently.

The early Egyptian, Chinese, Greek, and Roman phy-

* Candidate's thesis for membership accepted by the Committee on Theses.

sicians attempted to allay the pain incident to surgical operations by the use of alcoholic beverages, drinks with narcotic properties, and narcotic inhalations. In medieval times the spongia somnifera, or sleep sponges, were very popular and quite generally used in an attempt to produce surgical anesthesia. In the Antidotarium of Nicolaus Salernitanus a very interesting account of these sponges is given: "Take of opium of Thebes one ounce, juice of hemlock, poppy capsules, juice of mandragora, juice of wood-ivy, of each, one ounce. Put all these into a vessel together with a new sponge which is just as it came from the sea and has not been in contact with fresh water. Place the vessel in the sun during the dog-days until the sponge is needed, moisten it with a little hot water and apply it to the patient's nostrils, and he will quickly fall asleep. When you wish to rouse him, apply the juice of fennel-root, and he will soon wake." This expresses all the confidence of our modern advertisements. The use of these "sleep sponges" was gradually discontinued because, if sufficiently large doses to produce narcosis were used, the drugs were distinctly dangerous, and in smaller quantities the results were disappointing. Also, as suggested in the Bibliotheca Osleriana, the sponges were abandoned partly because of the introduction of the tourniquet for amputations and operations upon the extremities.

The ophthalmic portion of the "Tetrabiblon" of Aëtius of Amida (502–574), which covers quite fully the ophthalmology of the ancients, makes no mention of any attempt at anesthesia in surgical operations. In Chapter LXVIII, in discussing the operation for trichiasis, the following comment is made: "As, however, a few patients, because of cowardice, can never bring themselves to take an operation . . . ." This, with similar references, leads one to believe that the ancients relied principally upon stalwart assistants in lieu of anesthesia to secure a quiet if not relaxed patient. That the patients were not always quiet is evident from another statement, regarding the operation for pterygium, in which Aëtius remarks that care must be observed in order to avoid cutting the lids.

In the early times suggestion or hypnotism probably accounted in a measure for the successful relief of pain by surgeons. This was often combined with some particular procedure for supposed anesthesia, comparable in merit to placing the fat of the crocodile or its powdered skin upon the patient's skin, a practice of the early Egyptians. Also, according to Plinius, the "Stone of Memphis" produced local anesthesia if it was mixed with vinegar and rubbed on the skin. The various methods for securing local anesthesia advocated from time to time were tried by enthusiastic followers, and later discarded by them since they probably lacked the same hypnotic ability as the advocates of the methods.

Pressure on the nerve trunks, particularly of the extremities, to produce anesthesia was used as late as 1870, but it was never a very popular procedure, since sufficient pressure to cause insensibility of the part supplied by the nerve was frequently painful and required considerable time, and satisfactory anesthesia was not often obtained. In addition, there was grave danger of inflicting pressure necrosis or permanent motor and sensory paralysis. This method was too uncertain and the danger was too great.

Cold as a means of producing local anesthesia was first introduced in the middle of the sixteenth century by Thomas Bartholinus. Various agents, such as ice, ice with salt, ether spray, and other rapidly evaporating fluids, have been used. In minor surgery carbon dioxid, ethyl chlorid, and ethyl bromid are still occasionally employed to cause freezing of the tissues and so produce local superficial anesthesia.

Repeated attempts to induce local anesthesia by the application or injection of sleep-producing drugs were made on the theory that a similar effect would be produced locally, which obviously resulted in failure to produce the desired local anesthesia.

A discovery of considerable importance which made possible our present methods of local anesthesia was the hollow needle for hypodermic injections which was introduced by Alexander Wood, of Edinburgh, in 1853. This important mechanical aid made it possible to introduce drugs into the tissues, and bring them in direct contact with the nerves supplying the part, so that when drugs that would produce local anesthesia were discovered, a means of using them to the best advantage was available.

It is hard for us, in this generation, to imagine, in our highly sensitive, nervous patients, even the simple procedure of removing a foreign body embedded in the cornea without the assistance of a local anesthetic, and a cataract extraction without the aid of anesthesia is beyond our comprehension. Although cataract extractions and other eye operations have been performed under ether and under chloroform anesthesia for the past eighty-seven years, the undesirable results incident to the use of ether and of chloroform, particularly in cataract extractions, are quite obvious.

The era of modern ophthalmic surgery really began in 1884 with the introduction of cocain by Koller, which permitted ophthalmologists to operate upon the eye of the conscious patient without causing pain. So it is during the past forty-nine years that ophthalmic surgery has made such tremendous strides due, in great measure, to the ability to produce local anesthesia.

Although the general effect of chewing coca leaves had been known for centuries, the alkaloid of cocain was unknown until 1855, when it was discovered by Gaedcke,[1] who called it erythroxylin. The anesthetic properties of the drug were not made use of until Koller[2] made his memorable presentation in 1884, nearly thirty years later. After this the use of cocain as a local anesthetic was recognized and quickly gained world-wide favor.

In prehistoric times the coca plant was cultivated in Peru and Bolivia. Moodie* depicts a prehistoric surgical opera-

* Moodie: Paleopathology, frontispiece, 1923.

tion in Peru. The surgeon is said to have in his cheek a quid of coca leaves which he applies to the wound to ease the patient's distress.

According to Braun,[3] Scherzer was the first to bring a large quantity of coca leaves to Europe. Later Woehler, of Göttingen, received some of the leaves, from which his pupil, Niemann,[4] isolated the powerful alkaloid and named it cocain. The first reports in regard to the anesthetic properties of cocain were made by Scherzer,[5] who noticed that the chewing of coca leaves caused a feeling of numbness of the tongue; this was also observed by Niemann. In 1879 von Anrep[6] investigated the local action of cocain upon the skin and conjunctiva. He noted the anesthetic action on the skin after the injection of a weak solution of cocain, but observed only the mydriatic action of the drug when it was instilled in the conjunctival sac. In 1880 Coupard and Bordereau[7] observed in animals the loss of the corneal reflex following the use of solutions of cocain.

Four years later Koller's report of his observations seems to mark the real introduction of cocain as an anesthetic agent. Although other investigators have claimed priority in the use of cocain as an anesthetic, Koller is usually given the credit, for, as Darwin[8] said: "In science the credit goes to the man who convinces the world, not to the man to whom the idea first comes." This new anesthetic was very favorably received, and during the next two or three months after Koller's communication in Heidelberg, September 15, 1884, many reports of its use appeared in the literature.

In December, 1884, Herman Knapp[9] published a complete summary of the literature in regard to the use of cocain in all branches of surgery. In this he credits Bull, of New York, as being, on October 8, 1884, probably the first surgeon in America to employ cocain for inducing anesthesia. Reports of enucleations with the use of cocain by Knapp, Cocks, and Turnbull are also included in the article.

The simple and effective method of a retrobulbar injection which was used by Knapp to produce anesthesia of the globe for enucleation deserves particular recognition. Superficial anesthesia was produced by the instillation of a 4 per cent. solution of cocain. By means of fixation forceps the globe was then forcibly drawn toward the nose, a needle was introduced as far as the posterior pole of the globe, and 6 minims of a 4 per cent. solution of cocain were injected. The eye was enucleated without pain.

Cocks instilled a 4 per cent. solution of cocain every three or four minutes during the operation. After raising the conjunctiva, he injected a 4 per cent. solution of cocain along each tendon of the recti muscles and made another injection in the orbit behind the globe.

Turnbull employed cocain by instillation only. After opening Tenon's capsule, cocain was instilled before each tendon was severed. The scissors to cut the optic nerve were then introduced, and after sponging thoroughly, several drops of a 4 per cent. solution of cocain were allowed to flow down the blades. After waiting for one minute the nerve was severed.

These operations are mentioned particularly because of the historic interest they possess. However, enucleations with local anesthesia did not meet with general approval, probably due to the alarming toxic effects that followed the strong solutions of cocain that were used.

Some years later, enucleation with local anesthesia was revived by Siegrist,[10] Löwenstein,[11] Seidel,[12] and others, using a weaker solution of cocain, procain, etc. At the present time enucleations are done easily and painlessly under local anesthesia, and with many surgeons it is the procedure of choice.

Infiltration with cocain near or into the nerves was first reported by Hall and Halsted,[13] who observed that the tissues supplied by the nerves so injected became anesthetic. The technique of this procedure, which is now spoken of as nerve block, has been greatly improved and is in general use.

The toxicity of cocain was quickly realized, but not until many unhappy results had followed its use, particularly in general surgery, in which larger quantities were used than in ophthalmic surgery. Many of the unfortunate accidents were probably due to the rapid injection and absorption of strong solutions of the drug. Also, epinephrin had not yet been discovered. Cocain still holds a very important position in ophthalmic surgery, although in many procedures it has been replaced by less toxic and more efficient drugs.

After the discovery of the chemical composition of cocain and its atomic grouping by Einhorn,[14] the synthetic preparation of this alkaloid became possible and served as a starting-point for interesting experiments that combined the anesthesiophore atomic group with new atomic groups. This chemical research resulted in the discovery of a number of new local anesthetics, such as holocain, eucain, and those of the orthoform group, and later stovain, alypin, and procain—certainly a triumph of an exact science.

In 1901 Takamine[15] isolated the active salts of the suprarenal gland and added epinephrin (adrenalin chlorid) to our pharmacopeia. This increased greatly the efficacy of local anesthesia, and also facilitated operative procedures in which considerable bleeding is encountered.

Until the introduction of ether in 1846, the success of operations upon the eye was greatly dependent upon the speed of the surgeon and the stoicism of the patient. Although the necessity for speed has long since been eliminated by the improved methods of both general and local anesthesia, some ophthalmic surgeons still extol the virtue of speed and place unwarranted emphasis and importance upon it.

Such drugs as cocain, ether, and chloroform were known for years before their anesthetic properties were fully appreciated and used. So also much of our knowledge of physiology and anatomy is allowed to lie dormant, and in the technique of local anesthesia, many of the advances and improvements are not given the recognition that they deserve.

THE SENSORY DISTRIBUTION

Since the aim of anesthesia is to eliminate pain, a consideration of the distribution of pain sense in the different tissues with which the ophthalmologist has to deal seems to be the most logical approach to the subject if we are to achieve our end.

No doubt the pain sense varies in different individuals, as does also the interpretation of pain by different surgeons. In the literature there are many examples of this, and the following case illustrates the point: An operation for the removal of a toe-nail was reported by Shaw,[16] who states that after the toe was wrapped in cotton saturated with cocain for a few minutes, the nail was divided and removed without pain.

According to Braun,[17] the skin, with its innumerable nerve-endings, is probably the most sensitive tissue in the body. Although the skin has a highly developed pain and tactile sense, which is more marked in some areas than in others, it can hardly be considered more sensitive than the cornea. This can very easily be demonstrated by touching the skin, and then the cornea, with a wisp of cotton. However, the skin is extremely sensitive to pain, and if we are to retain the confidence of the patient, it is well to avoid causing unnecessary pain. When introducing the anesthetic agent, the pain caused by piercing the skin may practically be eliminated if the skin is rendered insensitive by first raising a small intradermal wheal, a procedure that will be discussed in greater detail further on.

The loose subcutaneous tissue possesses very little if any sensibility, although numerous conducting nerves containing sensory fibers for the skin traverse this area. Pain may be produced by cutting or by making traction on these nerves, but, as a rule, no pain will be experienced when a needle traverses the subcutaneous tissue unless it comes in contact with one of the small sensory nerve trunks.

In this respect, the orbital tissue corresponds to the subcutaneous tissue, and the introduction of a needle, as is done in orbital injections, is practically painless if the skin has first been anesthetized by producing a small intradermal wheal, provided the periosteum has not been pricked with the needle and the muscles and nerves are avoided.

The nerve distribution in muscles is practically the same as that in connective tissue, so that very sharp pain is caused if the sensory nerves are touched. However, if the nerve is not encountered, a needle may be introduced into healthy muscle tissue without causing pain. Muscle fascia and the surrounding connective tissue are distinctly sensitive, so that if the needle is passed through these without first anesthetizing the parts, pain is experienced.

Tendon tissue appears to be without sensibility. However, the connective tissue covering the tendon and the tendon sheaths possess a varying degree of pain sense, probably due to the nerve-endings in these tissues.

Joint capsules, ligaments, synovial membranes, and periosteum are extremely sensitive, and if they are pricked by the needle considerable pain may be caused.

There seems to be some difference of opinion in regard to the sensitivity of the bones, but in general we can consider them as having very little pain sense. This is not true of the medulla of long bones, in which, however, sensibility is not marked. Cartilage is insensitive, but the perichondrium is well supplied with nerves and is very sensitive to pain.

As the margins are richly supplied with sensory nerves, they are the most sensitive part of the eyelids. Although the conjunctiva and cornea are extremely sensitive, they can easily be rendered insensitive by the instillation of a few drops of some anesthetic agent.

THE MENTAL ATTITUDE OF THE PATIENT AND THE SURGEON

In operations performed under local anesthesia, particularly in ophthalmic surgery, the proper mental attitude of both the patient and the surgeon is so important that a careful consideration of this subject seems to be warranted.

Often the entire important procedure of producing anesthesia is consigned to the assistant or intern, and quite properly too, provided he has been instructed adequately and is sufficiently familiar with the technique. In visiting large clinics occasionally one sees patients who are so frightened by the preliminary preparation that the surgeon finds it difficult to quiet them and to regain the confidence necessary to obtain their full cooperation.

Apprehension is usually the greatest cause of suffering before the operation. In order to assure the patient that every precaution will be taken to insure his safety and comfort, it is necessary to inspire confidence, and the surgeon who can obtain this rarely encounters a patient who "behaves badly." The patient is most vitally interested in having a successful result, so, if he does not cooperate, it is frequently the fault of the surgeon.

Certainly, in most instances, the surgeon begins with the advantage of having the patient's confidence, otherwise he would not have entrusted his most valuable possession, sight, to that surgeon. The operator should strive to strengthen this confidence and endeavor in every way possible to avoid undermining it. The aim of all surgeons is to secure good results. With operators of equal surgical skill, the one who gains the patient's confidence will undoubtedly have the greatest number of good results.

Local anesthesia demands and allows deliberation and care in all the manipulations of the operator. A confident, orderly atmosphere in the hospital, particularly in the operating room, and a comfortable, well-padded operating table, invite complacency.

In the preparation of patients, careful attention should be given to the minor details. Patients are particularly sensitive at this time, so that the instillation of a drop given without warning, or getting soap, iodin, or the like in the eye, greatly upsets the patient's equilibrium. Hurried or inefficient attempts to produce anesthesia may inflict unnecessary pain. Even the slightest needle prick will, in certain patients, cause considerable pain, for at the time of introducing the anesthetic the patient is most apprehensive, his sensations for pain are greatly exaggerated, and each succeeding needle prick seems to be of increasing intensity. It is, therefore, of the greatest importance to induce anesthesia painlessly in order to retain and strengthen the patient's confidence.

Haste should be avoided, and the operation should not be attempted until complete anesthesia has been secured. Any complaint of pain indicates usually the inefficient administration of the anesthetic rather than a defect in the anesthetic procedure, agent, or patient. It is best not to proceed with the operation until complete anesthesia is obtained, and then it will rarely be necessary to resort to the well-known "vocal anesthesia." If all does not go well, scolding and blaming the patient, assistants, or nurses, or charging faulty instruments indicates usually a lack of self-control on the part of the surgeon.

In a limited number of patients the temperament or mental make-up offers difficulties. Patients undoubtedly differ to as great an extent in their mental as they do in their physical characteristics, and so they must be approached as differently as one would approach the various surgical conditions encountered.

Fear is the main barrier that prevents us from operating upon many children under local anesthesia. An experienced nurse who has won the confidence of a child can often engage its attention with interesting conversation that allows the operation to proceed smoothly. In many operations upon adults if their attention can be diverted, the operation will be easier and pleasanter for all concerned. Remarks such as "Did that hurt?" and "We are almost finished" should certainly be avoided.

While the use of a sedative or hypnotic, such as one of the barbituric acid group, before operation aids greatly in giving one a confident, quiet, and complacent patient, still it is of secondary importance, and should be considered only as an aid. The barbituric acid group of sedatives have the added value of counteracting to some extent the toxic action of the anesthetic agent.

LOCAL ANESTHETIC AGENTS

Since the advent of cocain chemists have produced numerous substitutes, some of which have, in large measure, replaced cocain, particularly in cases in which the anesthetic agent is injected for block or infiltration anesthesia.

A consideration of all the local anesthetic agents is obviously unnecessary. Only a few of the more generally accepted agents that are particularly suited to ophthalmic surgery will be considered. For instillation anesthesia, cocain, holocain, and butyn are the agents more frequently used, although pantocain is gaining rapidly in popularity.

Cocain.—Cocain hydrochlorid is the alkaloid of cocain that is generally used as an anesthetic agent. It is a white, crystalline powder, readily soluble in water and in alcohol. According to the report* of the Committee on Local Anesthetics in Ophthalmic Work of the American Medical Association, cocain may be sterilized by boiling without impairing its efficacy. Braun[18] states that no material loss of cocain follows a single rapid boiling of a small quantity of the solution, whereas repeated boiling of large quantities causes a diminution in the cocain content with a diminished activity of the solution.

To prepare a fresh sterile solution of cocain, Mikulicz recommends dissolving the cocain in alcohol in a sterile flask stoppered with cotton, and when the alcohol evaporates adding sterile water or saline solution to the residue.

According to the report of the Committee on Local Anesthetics in Ophthalmic Work of the American Medical Asso-

* Tr. Sect. Ophth., A. M. A., 1921.

ciation, the addition of five grains of boric acid powder to each ounce of solution tends to preserve the solution so that it will remain active for a longer time.

The physiologic action of cocain is that of a protoplasmic poison. It paralyzes temporarily, and without permanent damage, the sensory and motor peripheral nerves, and if brought in direct contact with sensory or motor fibers, it causes them to lose their power to transmit impulses. The sensory fibers are affected more quickly and easily than the motor fibers.

It is generally agreed that for infiltration or block anesthesia there are safer and better drugs than cocain. In referring to infiltration or block anesthesia, Braun[19] dismisses cocain as follows: "Cocain, at least in surgery, has become obsolete." Labat[20] states that "cocain has been practically discarded except for contact anesthesia of mucous membrane."

General cocain poisoning will be considered very briefly, since such highly toxic drugs as cocain are no longer accepted for infiltration or block anesthesia, and in the amounts used in ophthalmologic practice it would be most unusual to have toxic symptoms develop from the use of cocain topically. In cases in which toxic symptoms do appear, the chief disturbance occurs in the central nervous system, which is most sensitive to cocain. In mild forms of poisoning shortly after the use of cocain there is a sudden, usually transient, attack of vertigo, which may become more severe, particularly if it is allowed to continue. Fainting, a small, compressible pulse, cold sweat, irregular and difficult respiration, formication, and cold extremities may be followed by loss of consciousness. The pupils become dilated and fixed. Vomiting is frequent.

Severe poisoning usually begins with epileptiform convulsions, exophthalmos, and loss of consciousness; death follows as a result of a paralysis of the respiratory center.

The local application of cocain causes contraction of the small capillaries and arteries, especially of the mucous membrane, resulting in a localized ischemia which is followed by congestion or dilatation of the vessels. While the newer local anesthetic agents have an anesthetic action similar to that of cocain, they do not cause ischemia.

For superficial or surface anesthesia, one instillation of a 4 per cent. solution of cocain produces adequate anesthesia in five minutes. For deep anesthesia, such as is required for cataract extractions, four instillations at three-minute intervals is the procedure that is usually followed, and that produces the maximum effect of the cocain in about fifteen minutes.

In addition to the anesthetic action on the eye, cocain dilates the pupil and causes a slight paralysis of accommodation. The corneal epithelium is also affected, becoming desiccated, particularly if the eyelids are not kept closed or the cornea is not kept wet with boric acid or some similar solution. The tendency to keep the eyelids open and not to wink following the use of cocain increases the possibility of the occurrence of this condition. Cocain will also devitalize the cornea, so that, if used for cataract extractions, a collapse of the cornea and delay in closure of the corneal wound are more frequently observed than with such anesthetic agents as butyn and holocain. For this reason, cocain is not so desirable for the operation of corneal transplantation, and it may account for the fact that some of the grafts become cloudy.

Cocain is used in from 1 to 10 per cent. solutions, but the 4 per cent. solution is generally preferred. In muscle operations some surgeons use powdered cocain over the operative field.

Except when contraindicated, epinephrin is instilled in conjunction with the anesthetic agent, in order to constrict the vessels, decrease bleeding, and prolong the anesthetic effect.

Sollman[21] states that for surface anesthesia the addition of an equal volume of 0.5 per cent. solution of sodium bicarbonate to a solution of cocain increases the activity of the cocain from one to two times.

Holocain.—Holocain (phenacain) was prepared in 1897 by Taeuber, by combining molecular quantities of phenacetin and phenetidin. Although the basic compounds of holocain are insoluble in water, the hydrochlorid is soluble up to 2.5 per cent. and is the salt that is used. Holocain is incompatible with alkalis and their carbonate bases, so that porcelain instead of glass dishes should be used in its preparation. It is considerably more toxic than cocain, and should never be used hypodermically. On instillation it produces considerable irritation, smarting, and congestion of the conjunctiva. The anesthetic effect is produced more quickly than with cocain. There is a slight antiseptic action. Holocain does not dilate the pupil, does not cause desiccation of the cornea, nor does it devitalize the cornea, as cocain does.

The solution of holocain may be sterilized by boiling without affecting its efficacy. A 1 per cent. solution has been quite widely used to produce surface anesthesia for tonometry and the removal of foreign bodies. It has also been used by some surgeons for intra-ocular operations, such as cataract extractions, and, with the use of epinephrin to cause ischemia, it is a very satisfactory topical anesthetic. However, holocain has been pretty generally replaced by butyn, which, in turn, is now being challenged by pantocain, because pantocain causes very little smarting when instilled in the conjunctival sac.

Butyn.—Butyn was introduced in 1920, and is a white, amorphous powder, synthetically prepared by Adams, Kamm, and Volwiler. It is freely soluble in water, and may be sterilized by boiling without affecting its efficacy. It does not deteriorate rapidly on exposure to light or air, possibly because it possesses certain antiseptic properties. Butyn causes a precipitation of sodium and other chlorids, so it should not be dissolved in a saline solution.

For instillation it is generally used in a 2 per cent. solution.

After a single instillation of a 2 per cent. solution of butyn, surface anesthesia is usually produced in one minute, and lasts from fifteen to thirty minutes. However, two instillations are preferable, allowing an interval of two or three minutes between instillations. All patients are not equally susceptible to the action of butyn, but with two instillations sufficient anesthesia is produced in practically all patients to permit quite deeply embedded foreign bodies to be removed without pain. With two instillations tonometry is less likely to be unpleasant, a point of some importance since the patient can more easily hold his eye quiet. Also, the patient may conclude that if this apparently minor procedure is so painful, an operation would be unbearable.

The depth, degree, and duration of the anesthesia are increased by further instillations. Four instillations of a 2 per cent. solution of butyn at intervals of three minutes produce profound anesthesia of the cornea and conjunctiva, and in five or ten minutes after the last instillation the maximum effect is reached. The average duration is about thirty minutes, but it may last as long as an hour. The first instillation causes considerable smarting and irritation and a slight hyperemia of the conjunctiva, which may be controlled with epinephrin.

The diameter of the pupil is not affected by butyn, nor is there any change in the intra-ocular pressure. Collapse of the cornea, so often noted with cocain in cataract extractions, is somewhat infrequent with butyn. The nutrition of the cornea is not affected, and desiccation of the cornea does not occur.

In the literature no toxic symptoms have been reported or found following the topical use of butyn in the conjunctival sac. The Research Committee of the Council on Pharmacy and Chemistry of the American Medical Association states that, when injected hypodermically into albino rats, butyn is two and one-half times more toxic than cocain.

In the report* of the Committee on Local Anesthetics of the Section on Ophthalmology of the American Medical Association, butyn is compared with cocain as a local anesthetic, and the unanimous opinion of the Committee is that, for surface anesthesia, butyn is superior to cocain, as it acts more quickly and is accompanied by fewer complications. There are no objectionable effects, such as dilatation of the pupil or desiccation of the cornea, and the anesthesia with a 2 per cent. solution of butyn is more profound than that with a 4 per cent. solution of cocain. Also, no toxic symptoms were noted following the instillation of a 2 per cent. solution of butyn in the conjunctival sac.

Pantocain.—Pantocain, a derivative of procain (novocain), is one of the newest local anesthetics. For instillation anesthesia its chief advantage over holocain and butyn is the fact that it causes very little smarting. It is an odorless, white, crystalline substance, readily soluble in water, and quite stable when exposed to light and air. It may be sterilized by boiling without decomposition and without affecting its efficacy. According to Wilmer and Paton,[22] it is compatible with epinephrin, atropin, homatropin, boric acid, pilocarpin, resorcin, scopolamin, and zinc sulphate.

Various reports agree that, when given subcutaneously, the toxicity of pantocain is ten times greater than that of procain, but as it is effective in one-tenth the strength of procain, the relative toxicity is therefore about the same as that of procain.

Schmidt,[23] Lundy and Essex,[24] Singer,[25] and Kies[26] report the use of pantocain topically for infiltration and for spinal anesthesia in over 10,000 cases, comprising a great variety of operations. They do not report having observed any toxic effects.

Schülein[27] recommends pantocain because of the prolonged action and the low cost of the drug. He states that with pantocain the duration of anesthesia is from four to

* J. A. M. A., February 4, 1922, lxxviii, p. 343.

six hours, whereas with procain it is only from one and a half to two hours.

Because pantocain has a powerful hypotonic action in aqueous solution, Wilmer and Paton advise the use of normal salt solution as a solvent. These investigators report its use in over 500 cases at the Wilmer Ophthalmological Institute, and state that it possesses definite advantages over other local anesthetics.

After two instillations in the eye, the first in the lower culdesac and the second on the cornea as the patient looks downward, surface anesthesia is produced in about one minute, and lasts about twenty minutes. There is some lacrimation, but practically no hyperemia. The corneal epithelium is not disturbed, and the pupil, accommodation, and tension are not affected.

For major operations, such as cataract extractions and corneo-scleral trephining, four instillations of a 0.5 per cent. solution of pantocain were used by Wilmer and Paton. In the trephine operations a subconjunctival injection of a 0.1 per cent. solution of pantocain was also given, and Wilmer and Paton state that complete anesthesia was produced in all the cases.

INSTILLATION ANESTHESIA

Superficial anesthesia sufficient for the removal of foreign bodies of the cornea, tonometry, and such minor procedures can be produced in from one to five minutes, depending upon the anesthetic agent used. Two instillations should be made. The patient is directed to look upward, the lower lid is drawn down, and several drops of the anesthetic are instilled in the lower culdesac. In two or three minutes the second instillation is given. The patient is asked to look downward, the upper lid is raised, and several drops of the anesthetic are allowed to flow under the upper lid and down over the cornea. In this way a more complete anesthesia is produced than if both instillations are given in the lower culdesac.

For deeper anesthesia, four instillations at three-minute intervals should be used, and in fifteen minutes the maximum effect is usually produced. To produce ischemia and obtain a bloodless field, as well as to prolong the anesthesia, several drops of epinephrin, 1:1000, are also instilled.

Procain (Novocain).—In selecting the anesthetic agent for regional or infiltration anesthesia, the first consideration should be that of safety. Secondly, adequate anesthesia should be produced quickly without injury or irritation to the tissues, and should be of sufficient duration to allow the surgeon ample time to complete the operation. Thirdly, the anesthetic agent should be easily available, prepared simply, and sterilized by boiling without deterioration.

Procain fulfils these requirements better than any local anesthetic agent yet produced. Braun[28] states that the toxic action of procain is less pronounced than that of any hitherto known anesthetic agent, and that it possesses scarcely any irritating properties. Labat[29] says: "Novocain has stood the test of many years and is the drug of choice." The Research Committee of the Council on Pharmacy and Chemistry of the American Medical Association reports that procain is the least toxic local anesthetic agent. The Committee on Local Anesthetics in Ophthalmic Work of the American Medical Association recommends it as the most desirable drug for infiltration anesthesia. Procain is now so generally accepted as the safest and best anesthetic for all regional and infiltration anesthesia that a consideration of other more toxic and less satisfactory drugs seems to be unnecessary.

The salt of procain crystallizes from alcohol in the form of needles which melt at a temperature of 156° C. It is soluble in equal quantities of water, producing a solution neutral in reaction, and readily soluble in physiologic salt solution. It is precipitated by alkaloid reagents such as sodium carbonate, forming an insoluble base. The crystals may be sterilized by autoclaving at 110° C., and the watery solution may be sterilized by boiling without deterioration.

Procain is rapidly and completely absorbed locally with no destruction of the tissues. As there is no peripheral effect on the blood vessels, the anesthetic effect of procain is of short duration, so that it is necessary to use epinephrin to prevent the rapid absorption of the procain. With the addition of a small amount of epinephrin to the procain, analgesia begins almost immediately after the injection and lasts two to three hours. Surgical anesthesia starts ordinarily in from five to ten minutes, and continues one and one-half to two hours.

Procain is not so well suited for anesthesia of mucous membranes by topical application, probably due to the fact that it does not completely penetrate these membranes.

Braun[30] states that the addition of 0.4 per cent. potassium sulphate to the procain solution greatly increases its anesthetic properties, and in this concentration produces neither local nor general injury. When used in weak solutions and in doses sufficient to produce surgical anesthesia, the toxicity of procain is negligible. Labat[31] gives the maximum dose for robust patients in good physical condition as 150 c.c. of a 1 per cent. solution and 60 c.c. of a 2 per cent. solution, and emphasizes the importance of observing the proper technique and injecting the solution slowly.

Although toxic symptoms are rarely encountered in ophthalmic surgery, in which such small quantities are used, still, if small doses of a 1 or 2 per cent. solution are injected rapidly or into the circulation, toxic symptoms may be observed. These symptoms are: rapid pulse, palpitation, frequent respiration, labored breathing, pallor of the face, cyanosis of the fingers, lips, and ears, nausea, vomiting, cold sweats, and blurred vision. The rapid pulse, palpitation, and rapid and labored breathing may also be due to epinephrin and are of short duration, lasting two to three minutes, and are not serious symptoms. If they do occur, the injection should be stopped, and if more serious symptoms, such as pallor, cyanosis, nausea, etc., develop, Labat[32] recommends the subcutaneous injection of the following cardiac stimulant:

Caffein	0.25 gm.
Spartein sulphate	0.05 gm.
Sodium benzoate	0.30 gm.
Strych. sulph.	0.001 gm. in 2 c.c. ampule.

After the patient has completely recovered, the injection of the procain may be resumed.

In the preparation of the solutions it is important to make isotonic solutions, as hypertonic solutions cause a shrinkage of the cells and hypotonic solutions produce a swelling of the cells; with either, a destruction of the tissue occurs. Physiologic salt solution is consequently the solvent of choice. To avoid error in preparing the solutions Labat[33] recommends the use of Neocain, the French preparation of procain, in capsules which contain 0.50 gm., weighed accurately and sterilized. For a 2 per cent. solution, one capsule in 25 c.c. of saline solution is used. For a 1 per cent. solution, one capsule in 50 c.c. of saline solution is used.

Labat emphasizes the importance of using only freshly prepared solutions, and of adding, just before use, five drops of colorless epinephrin, 1:1000, to 100 c.c. of the anesthetic solution, irrespective of the strength of the solution. Until 1920 Labat used 20 drops of epinephrin to every 100 c.c. of procain, but he has gradually reduced the quantity to five drops and observes that toxic symptoms are less frequent and the reactions not so pronounced. Solutions of epinephrin that have become brown or pink in color should be discarded.

For the average patient the maximum dose of epinephrin given subcutaneously or intramuscularly is 10 minims. In elderly patients—those with arteriosclerosis and other lesions of the vascular system or diabetes—who are quite frequently encountered in ophthalmic practice, the amount should be reduced to five drops.

As the quantity of anesthetic solution used in ophthalmic operations is so small,—rarely more than 10 c.c.,—one need be concerned but little about exceeding the maximum amount of epinephrin that it is safe to use if the proportion of 5 or 10 drops to 100 c.c. of anesthetic solution is observed. The advantages usually ascribed to adding epinephrin to the procain solution are that it hastens, intensifies, and lengthens the anesthetic action of the procain.

For minor operations that are performed in the office or hospital, often requiring less than 1 c.c. of procain, a very convenient and economical preparation is offered by several pharmaceutical houses. The procain and epinephrin are furnished in ampules containing 1 c.c. of a 2 per cent. solution of procain with epinephrin, 1:50,000 or 1:20,000, sterile and ready for use. Larger ampules can also be procured, so that for the ophthalmic surgeon whose operations are somewhat scattered the use of such ampules, in which the dose is accurate and the percentage assured, is a decided advantage for both office and hospital work.

INSTRUMENTS

The 5 c.c. Labat syringe is very satisfactory for making injections in the major eye operations in which orbital injections and those requiring more than 1 or 2 c.c. of solution are indicated.

The chief advantage of the Labat syringe is the bayonet lock which prevents the needle from becoming detached during the injection. It is, however, in every respect a well-constructed syringe, with a transparent glass barrel and a plunger of metal ground to fit each other tightly.

To sterilize the syringe, Labat recommends the following: Separate the plunger from the barrel and place them in cold water; raise the water to the boiling point and boil for ten minutes. Cool the plunger in cold sterile water and the barrel between dry sponges. After using, cleanse thoroughly with alcohol or ether and wipe dry.

The type of steam sterilizer used in many hospitals, and which is usually hot, is not suitable for this method of steril-

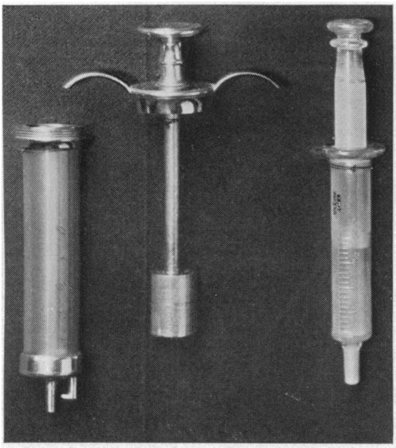

Fig. 1.—Labat's 5 c.c. syringe and the Luer 2 c.c. all-glass syringe.

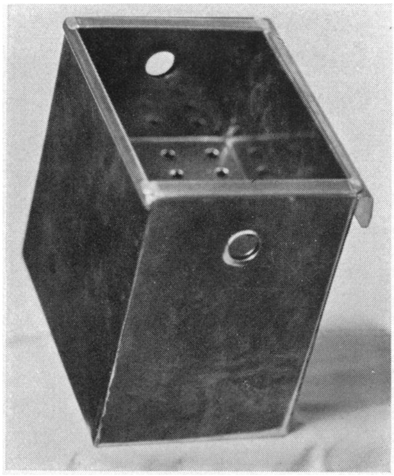

Fig. 2.—Metal container for sterilizing syringes.

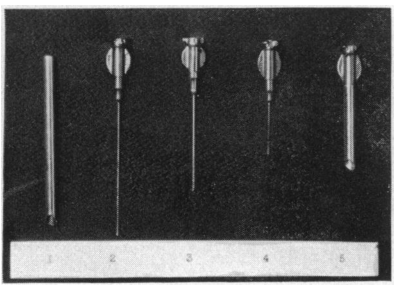

Fig. 3.—Needles: 1, Protective metal shield for needle. 2, Labat needle No. 2, 5 cm. in length. 3, Same size as Labat needle No. 2, 3.5 cm. in length. 4, Labat wheal needle No. 1, 2 cm. in length. 5, Needle with protective metal shield.

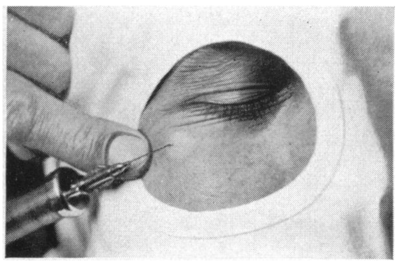

Fig. 4.—Intradermal wheal.

ization. If the syringes are placed in the boiling water of the sterilizer, this seems to affect the union between the metal ends and the glass barrels so that they are not air-tight; also the glass may break. To overcome this difficulty a small metal container (fig. 2) may be used, in which the syringes are placed in cold water and the whole put in the sterilizer. The sides of the container are of sufficient height to prevent the boiling water of the sterilizer from flowing over the sides. By means of a hook (fig. 2), the container is hung on the inside of the sterilizer.

If preferred, the syringes may be sterilized in alcohol, a method which is quite satisfactory. By drawing sterile water up into the barrel and expelling it, the alcohol is washed from the syringe.

Needles.—The rust-proof, platinum iridium needles are very satisfactory, and a great improvement over the old steel needles which rust so easily and become plugged.

Three sizes of needles are desirable: the Labat No. 1 wheal needle, which is an extremely fine needle, 2 cm. in length; the Labat No. 2 needle, which is 5 cm. in length; and the third type, which is 3.5 cm. in length, and the same caliber as the Labat No. 2 needle. These needles are supplied with protective metal shields which prevent the points from becoming dulled or turned (fig. 3).

The needles are sterilized by boiling for five minutes. After using, they should be washed in cold water, boiled, dipped in alcohol or ether, and dried by blowing air through them with the syringe; they are then oiled and placed in their shields.

Intradermal Wheal.—Before piercing the skin for an injection, an intradermal wheal should be made to avoid causing unnecessary pain. For this purpose the No. 1 wheal needle is used. The skin is stretched with the index finger and the needle is held flat against the skin. The point of the needle is then introduced with the bevel edge up just under the epidermis, and a little procain-epinephrin solution is injected, which gives the site of the injection a somewhat bleached appearance, and the skin immediately becomes insensitive.

For the skin of the lids, which is extremely thin and loose, a little fold may be made with the thumb and index finger, the needle inserted at the summit of the fold, and a similar wheal raised.

NERVE BLOCK, FIELD BLOCK, AND INFILTRATION ANESTHESIA

In speaking of local anesthesia, one usually refers to a procedure by which a part of the body is rendered insensitive to pain, whether by topical application of the anesthetic agent, infiltration at the site of the incision, or regional anesthesia, which Labat[34] defines as "the result of a certain number of delicate surgical procedures by which it is possible to control pain temporarily by interrupting the sensory nerve conductivity of any region of the body. Motor function is occasionally interfered with."

Local anesthesia may be produced in two ways:

1. By nerve block, which is the injection of the anesthetic agent around the nerve supplying the part, thus interfering with the conductivity of the nerve.

2. By field block, which is a procedure that produces a wall of anesthesia that renders the operative field insensitive to pain. The latter is accomplished by producing a wall of anesthesia that blocks all the nerves supplying the operative field, and does not aim at any individual nerve, as in nerve block. First an intradermal wheal is raised through which the needle is introduced perpendicularly; the solution is slowly injected as the needle advances until it reaches the deepest layers of the soft tissues to be injected. The needle is then withdrawn until the point reaches the subcutaneous tissues, and the solution is slowly injected as the needle is withdrawn. The direction of the needle is then changed, advancing the point along the line to be blocked and reintroducing the needle

obliquely. This is repeated several times, inclining the needle more obliquely each time. A second wheal is then raised in line with the first, and the procedure is repeated until a wall of sufficient length is produced. It is often necessary to surround the operative area with a wall of anesthesia, depending upon the nerve supply of the part to be operated on. This procedure is applicable in some plastic operations and the principal advantage is that the operative field is not infiltrated, which might interfere with healing or distort the tissues of the part involved. Also, if there is much scar tissue, it cannot be infiltrated satisfactorily. With field block the anesthesia lasts longer, because the anesthetic solution does not escape when the incision is made as it does when it is infiltrated along the site of the incision.

In regional anesthesia it is extremely important to visualize the anatomy of the operative field, particularly with regard to the nerve distribution and the bony landmarks that serve as a guide for the various injections. An accurate knowledge of the anatomy is obviously essential, and it is assumed that such has been acquired. The only references to anatomy will be in connection with the technique employed.

Infiltration Anesthesia.—After raising an intradermal wheal, the needle is introduced through the wheal, and the anesthetic solution is injected slowly as the needle advances. If there are any large vessels in the vicinity, one should aspirate occasionally to make sure that the needle has not entered a vessel.

Subconjunctival Injection.—For this procedure a 2 per cent. solution of procain, with one drop of epinephrin, 1:1000, in 10 c.c., or the prepared ampules of procain and epinephrin are used. For subconjunctival injections a 1 or 2 c.c. all-glass syringe, with a fine, short needle, similar to the No. 1 wheal needle, is more convenient than the larger Labat syringe. The lids are held open with the thumb and finger of the left hand or with a speculum. The point of the needle is slid gently over the conjunctiva until a fold appears in front of the point; the syringe is then rotated, producing a boring effect. In this way even a dull needle passes easily and gently through the conjunctiva without necessitating the use of forceps or quick jabbing.

Many excellent articles dealing with anesthesia in ophthalmology have been published, but often specific and minute details regarding the technique have been omitted, the authors evidently assuming that their readers were familiar with them. From personal observation, this seems hardly to be justified; however, it is with some temerity that space is given to these important, although well-known academic details.

Retrobulbar Injection Within the Muscular Cone or Cone Injection

Indications.—1. Enucleation and evisceration. 2. Intraocular operations. 3. Operations in which there is considerable traction on the muscles, as, for example, advancements.

The retrobulbar injection should be preceded by the usual instillation anesthesia.

A small intradermal wheal is first raised a short distance below the inferior temporal margin of the orbit. A 2 per cent. solution of procain, with a drop of epinephrin, 1:1000, to 10 c.c., is used. When injecting the right orbit, the patient is directed to look upward and to the left. The No. 2 needle, 3.5 cm. in length, is then introduced through the wheal, and the skin is moved upward with the needle so that the point just clears the inferior orbital margin. The needle is then directed upward and inward, midway between the external and inferior recti muscles, and advanced toward the apex of the orbit for a distance of from 2.5 to 3.5 cm., depending upon the size of the orbit; as the needle advances a small quantity of procain solution is injected continuously. When the needle has reached a depth of from 2.5 to 3.5 cm., one should aspirate before injecting the solution, to make sure that the needle has not entered a vessel. However, in this

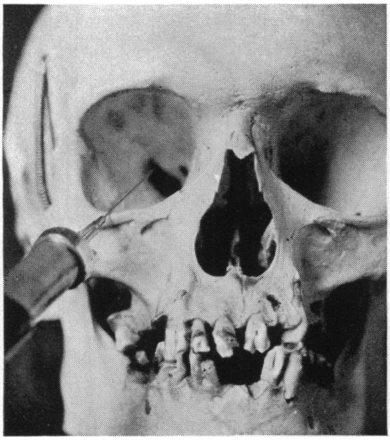

Fig. 5.—Skull showing position of the needle for retrobulbar injection within the muscular cone.

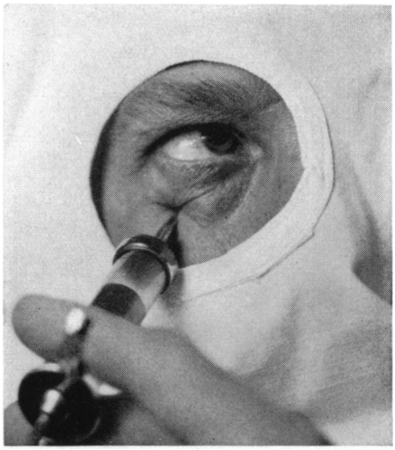

Fig. 6.—Retrobulbar injection within the muscular cone.

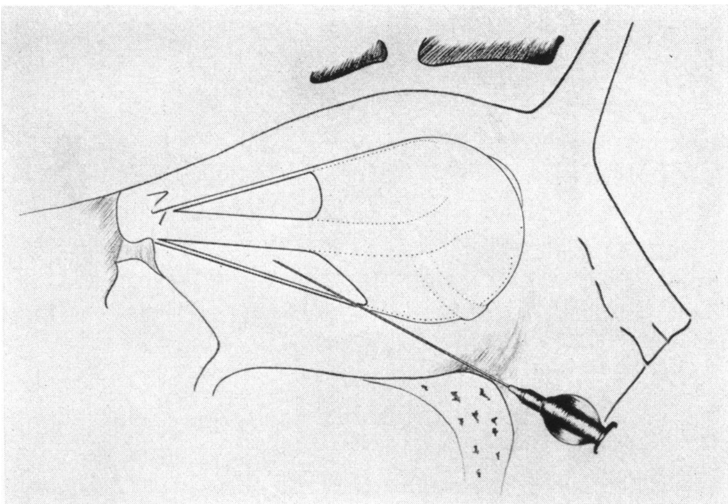

Fig. 7A.—Diagrammatic sketch showing the eye turned up and away from the site of the injection, thus moving the fascial extension forward and up out of the way.

location it is practically impossible to enter a vessel unless there is an anomaly, since the vessels here are normally smaller than the needle. From 1 to 2 c.c. of the procain solution is injected slowly, care being taken not to produce undue proptosis by giving too large an injection. For the majority of globe operations 1 c.c. is usually sufficient, but for some muscle operations and for enucleations 2 or 3 c.c. may be injected, as a slight degree of proptosis is of no importance and, particularly in painful eyes, a little more procain is desirable.

If a small amount of the procain solution is injected as the needle is introduced, practically no pain will be experienced. When the resistance of the septum orbitale is encountered, it is well to pause to allow the procain to take effect. Slight resistance will sometimes be felt when the needle enters the muscular cone.

When the needle is withdrawn, pressure should be made at once over the site of the injection, pressing the skin against the malar bone at the orbital margin, thus preventing bleeding at this point. For a few moments slight pressure is also exerted on the globe with a little rotary motion, so that the procain solution is more thoroughly diffused within the muscular cone. The operation may then be begun.

By means of the injection within the muscular cone all the sensory nerves to the eyeball are blocked and complete anesthesia of the globe is obtained regardless of how greatly inflamed or painful the eye may be. Pressure upon the inflamed eye, which before the injection caused severe pain, is not noticed now. The recti muscles are also rendered practically insensitive to traction.

With such complete anesthesia of the globe, and the eye practically immobile, together with a paralysis of the orbicularis, operations upon the globe can be performed with the same deliberate precision that one can use when operating upon a pig's eye.

The injection within the muscular cone also causes a paresis of the recti muscles, so that the patient cannot easily look down. Therefore, for such operations as cataract extraction, it is advisable to use a suture under the superior rectus, but with the recti inactive, very little traction is required to hold the eye in the desired position. Also, better fixation of the globe is thus obtained.

When the eye is red and inflamed, as in acute glaucoma, a subconjunctival injection should also be given, since the inflamed conjunctiva is not well anesthetized by topical application. Only the conjunctiva immediately surrounding the cornea for a distance of about 3 or 4 mm. is rendered insensitive by an injection within the muscular cone, since its nerve supply is from the ciliary nerves which are within the cone. The rest of the conjunctiva is innervated by the supra-orbital, supratrochlear, infratrochlear, infra-orbital, and lacrimal nerves, all of which are outside of the muscular cone and are not reached by the injection within the cone. If the eye is inflamed, less pain is caused if the subconjunctival injection is given after the retrobulbar injection. For the subconjunctival injection the needle may be introduced through the insensitive conjunctiva directly surrounding the cornea, and if succeeding injections are made through anesthetic blebs, very little pain will be experienced. In this way, pain due to the use of fixation forceps and to suturing the conjunctiva after enucleation is avoided in eyes that are inflamed and painful.

Having the patient look upward and away from the site of the injection allows easier access to the muscular cone. The extension of the fascial sheath of the muscles which closes the spaces between the recti muscles for a little distance back of the globe is in this way moved forward and upward out of the way, so that the needle does not strike it, as shown diagrammatically in figure 7 A. If the needle does strike the sheath, pain ensues. The sheath is also somewhat tough and the needle does not penetrate it easily, thus causing the globe to rotate, which to some extent interferes

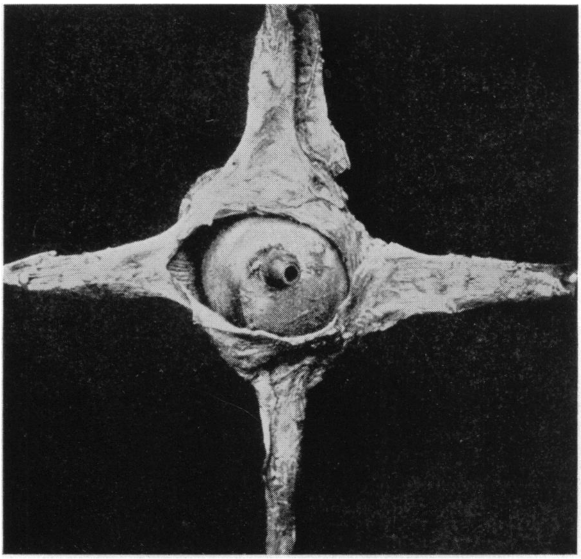

Fig. 7.—Posterior view of the eyeball, showing the fascial sheaths and in part the fascial extension which closes the spaces for a little distance back of the globe (from Whitnall).

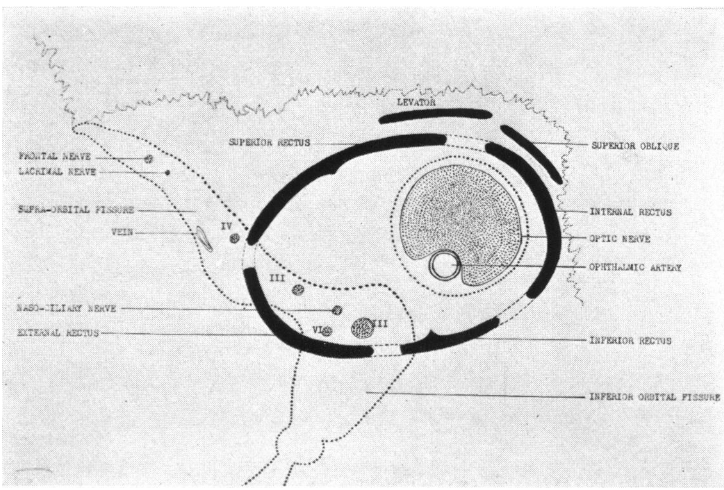

Fig. 9.—Scheme showing the position of the annulus of Zinn and the relative position of the nerves which enter the orbit through the superior orbital fissure both within and without the annulus (after Whitnall and Poirier).

with the introduction of the needle and the equilibrium of the patient.

An injection of procain within the muscular cone is apparently held within the cone, since the nerves outside of the muscular cone are rarely affected. How is the solution of procain held within the muscular cone, since there is no demonstrable fascia between the recti muscles, posterior to the globe, as they converge to their attachment at the apex of the orbit? Anteriorly, the escape of fluid is prevented by the globe, surrounded by Tenon's capsule, and by the adjacent margins of the sheaths of the four recti muscles, which are continuous with one another with a wide sweep between them, as shown in figure 7, from Whitnall.[35] In this manner an intramuscular membrane is formed which, according to Whitnall, exists for a short distance behind the globe. Beyond this the muscles converge to their attachment through the annulus of Zinn at the apex of the orbit, and their margins become closer together, leaving comparatively little space between them. In this location the escape of the procain solution is probably prevented, or at least retarded, by the closely packed layer of fat with its connective-tissue reticulum.

According to Whitnall,[36] the orbital fat fills the entire space in the orbit not occupied by other structures. It varies in consistency in different regions. Within the muscular cone the fat has the appearance of large and loosely connected lobules, broken up by the passage of the nerves and vessels. Outside of the muscular cone the fat is more firmly and closely packed, and contains a quantity of connective tissue which is closely attached to the muscular sheaths. No doubt this connective tissue serves as a sufficient barrier so that the anesthetic solution is held within the cone, thus causing anesthesia or blocking of the nerves that traverse it; namely, the nasociliary, long and short ciliary, ciliary ganglion, optic nerve, and all the motor nerves except the trochlear or fourth (fig. 8).

In some methods of intracapsular cataract extraction a decrease in the intra-ocular tension seems to be an advantage, as it lessens the possibility of vitreous prolapse. In extraction with capsulotomy it is often more difficult to express the lens when the tension is decreased. In deeply set eyes the operation is somewhat facilitated if the eye is slightly proptosed. The decrease in the intra-ocular tension following the cone injection of procain and epinephrin may be accounted for by the constricting action of the epinephrin on the arteries entering the globe, which would tend to decrease the amount of blood entering the globe, but

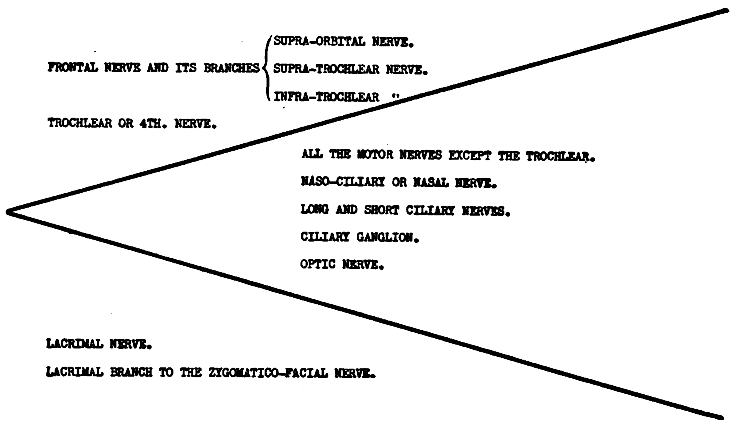

Fig. 8.—Diagram of nerves within and outside of the muscular cone.

would not impede its exit through the venae vorticosae since the solution does not reach them, located as they are in the episcleral space. The free anastomosis of the venae vorticosae and other orbital veins with the facial vein would allow free exit of the blood.

For cataract extractions and other globe operations it is advisable to begin the surgical procedure soon after the cone injection, as it lowers the intra-ocular tension. This point is particularly emphasized by Elschnig, who begins the operation as soon as the injection is given. With a lowered tension the iris may not prolapse well in corneo-scleral trephinings, an incident which may be quite embarrassing. However, in glaucomatous eyes the tension is lowered very slightly, probably because the venae vorticosae are compressed, due to the angle at which they pass through the sclera.

Newly formed aqueous, which Duke-Elder[37] terms "plasmoid aqueous," contains a larger proportion of colloidal molecules or plasma proteins than does the normal aqueous. If this is a dialysate due to a dilatation of the capillaries of the ciliary body following the escape of the normal aqueous, then the cone injection of procain and epinephrin would not only be of value as an anesthetic but, as pointed out by Friedenwald,[38] would prevent a postoperative rise of tension. The action of the epinephrin reduces the edema of the intraocular tissue, particularly that of the ciliary body and processes. Thus the dialysis is limited and more nearly normal aqueous is formed, which diminishes the occurrence of so-called plastic iritis and the formation of synechiae. The epinephrin in the cone injection does not cause dilatation of the pupil, as might be expected.

This simple and efficient method of obtaining complete anesthesia of the globe has been revived, in a great measure, by the investigations of Löwenstein,[11] under the direction of Elschnig. With a view to injecting the ciliary ganglion in order to obtain complete anesthesia of inflamed and painful eyes for enucleation operations, an accurate study of the exact location of the ciliary ganglion was made. By using a 5 cm. needle and introducing it through the conjunctiva temporally, just below the margin of the external rectus, for a distance of 4.5 cm., Löwenstein found the point to be just in front of the ganglion. Injections made in this manner within a few minutes produced complete insensibility of the most painful eyes.

Later Elschnig modified the technique and introduced the needle through the skin at the inferior temporal margin of the orbit, rather than through the conjunctiva. The suffering caused by traction and pressure on painful eyes is thus avoided. The method also allows easier access to the muscular cone. In observations on the cadaver, Löwenstein noted that the optic nerve was often pierced with the 5 cm. needle, and that dyes could be injected into the optic sheath quite readily without any dye being found free in the orbit. This indicates how easily the optic nerve may be injured if a 4.5 or 5 cm. needle is used. The procedure of Löwenstein has been referred to as injecting the ciliary ganglion. It is not surprising that many surgeons hesitated about trying it, and well they might, if taken literally. It would indeed require the most exact technique to inject the tiny elongated ganglion, 2 mm. in length, lying as it does in the orbital fat within the muscular cone, about 1 cm. in front of the annulus of Zinn, between the external rectus and the optic nerve, close to the ophthalmic artery. The fact that it is desirable to block the ciliary ganglion for many operative procedures is not questioned. But this can be done safely and easily by using a 3.5 cm. needle and injecting the anesthetic solution more anteriorly within the muscular cone. In this location, due to the loosely connected fat globules, the solution diffuses quickly and permeates thoroughly the ciliary ganglion, a fact undoubtedly appreciated by Herman Knapp[9] nearly fifty years ago, when he employed and reported the use of a retrobulbar injection to produce anesthesia of the globe for enucleation.

Duverger,[39] after experiments on the cadaver with needles of various lengths, concluded that a 3.5 cm. needle is preferable for all orbital injections except those to be made at the extreme apex, and for these he found that the 4.5 cm. needle was just long enough to reach the optic foramen, but not to pass through it.

With the 3.5 cm. needle Duverger was unable to pierce the optic nerve even after removing a portion of the orbital wall, so that he could observe the point of the needle which had been introduced at the inferior temporal margin of the orbit.

When the point of the needle approached the nerve it always eluded it, because in this location the nerve is quite freely movable. The same property applies to the vessels here. They are also very small, so that the risk of injuring them is slight. Nevertheless, orbital hemorrhage is often mentioned as an objection to retrobulbar injections. Data on over 8,000 retrobulbar injections showed eight orbital hemorrhages, five of which were admittedly due to faulty technique. In no instance was the eye damaged. If a 4.5 or 5 cm. needle is used and the point is carried to the apex of the orbit, obviously a vessel or the optic nerve might easily be pierced, because here they converge to reach their bony exits and are quite fixed. This danger is avoided by the use of a 3.5 cm. needle.

Duverger also considered that the best approach for injecting the muscular cone is from the inferior temporal margin of the orbit.

Elschnig, in a personal communication, November 18, 1930, stated that he had been using orbital injections regularly for more than five years. In about 2,000 intrabulbar operations, four orbital hemorrhages occurred, which Elschnig attributed to faulty technique. They did no harm, although in one case the operation had to be postponed until the following day.

Another communication, from Dr. A. S. Green, states that in approximately 5,000 intra-orbital injections there were three intra-orbital hemorrhages with no injurious results, the operation being postponed merely for a few days to allow the blood to absorb.

From the diagram showing the nerves within and outside of the muscular cone (fig. 8) it is obvious that if more extensive orbital operations, such as exenterations, are to be performed, it will be necessary for the anesthetic solution to reach the nerves outside of the muscular cone as well as those within it.

COMPLETE ANESTHESIA OF THE ORBITAL CONTENTS

Indication.—Extensive orbital operations, such as exenteration.

It is necessary to block the frontal, lacrimal, and infra-orbital nerves, which are outside of the muscular cone, as well as those which are within the cone.

The frontal nerve is the largest branch of the ophthalmic nerve. It enters the orbit through the superior orbital fissure above the muscles and runs forward immediately beneath the periorbita of the roof of the orbit. Its two main branches are the supratrochlear and supra-orbital nerves. Their terminal branches supply mainly the skin and the conjunctiva of the upper lid, the side of the nose, the frontal sinus, and the skin of the forehead. There is considerable overlapping of the sensory nerve supply to the lids and the surrounding cutaneous area, so that no sharp line can be drawn. Branches from the frontal nerve often supply parts of the lower lids, and branches from the infra-orbital nerve supply parts of the upper lids. The cutaneous distribution of all the nerves about the eye varies greatly.

The lacrimal nerve is the smallest branch of the ophthalmic nerve. It enters the orbit through the superior orbital fissure just below the frontal nerve, so that both of these nerves can be blocked with one injection. Its terminal branches supply the skin and the conjunctiva of both lids temporally and the lacrimal glands.

The superior maxillary nerve enters the orbit through the inferior orbital fissure at about its mid-point and is then called the infra-orbital nerve.

The infra-orbital nerve runs forward along the floor of the orbit, beneath the periorbita, in the infra-orbital groove and canal. In the forepart of the infra-orbital canal, a few millimeters from the foramen, the anterior superior dental branch is given off. This small branch passes through minute osseous canals to supply the lower part of the lacrimal sac and the nasal duct, as well as the incisor and canine teeth. The infra-orbital nerve passes through the infra-orbital foramen and divides into its terminal branches to supply the conjunctiva and skin of the lower lid, the skin of the cheek, the skin of the side of the nose, and the skin and mucous membrane of the upper lip.

The zygomatic nerve, a branch of the superior maxillary nerve, is given off in the pterygopalatine fossa. It enters the orbit through the inferior orbital fissure and divides into two branches. The temporal branch communicates with the lacrimal nerve, so that in order to secure complete anesthesia it should be blocked. The malar branch, which passes through the zygomatic foramen to supply the skin of the cheek, is not involved in the present discussion.

The two diagrams show at a glance the branches and sensory supply of the ophthalmic division of the trigeminal nerve and the maxillary or second division of the trigeminal nerve.

Block of the Frontal and Lacrimal Nerves

Blocking of the frontal and lacrimal nerves is accomplished by injecting the superior orbital fissure through which both the frontal and the lacrimal nerves enter the orbit.

A wheal is raised at the external orbital margin, just above the external canthal ligament. The No. 2 needle is then introduced through the wheal, and the point is kept in close contact with the bone of the external or lateral wall of the orbit. As the point strikes the sloping wall of the orbit, it is necessary to withdraw the needle partly two or three times and redirect the point more nasally toward the apex of the orbit. The needle should be kept in close contact with the bone, but in the same horizontal plane. At a depth of 4.5 cm. the needle should have arrived at the superior orbital fissure. As the needle is introduced a small quantity of procain solution is injected, and when the fissure is reached, 2 c.c. are injected.

OPHTHALMIC DIVISION OF THE TRIGEMINAL NERVE

Branches			Sensory Supply
Frontal	Supra-orbital	Internal frontal	Eyelids
		External frontal	Diploë and frontal sinus
	Supratrochlear	Branch to infratrochlear	Skin of forehead above head of eyebrow Skin and conjunctiva of upper lid and side of nose
Nasociliary	Sensory root to ciliary ganglion Two long ciliary nerves		Eyeball: Cornea; Iris; Ciliary body; Bulbar conjunctiva immediately around the cornea; Sheath of optic nerve
	Infratrochlear or external nasal		Internal canthus Skin and conjunctiva mainly of upper lid, some of lower lid Root of nose Lacrimal sac Canaliculi Caruncle
	Internal nasal		Mucous membrane and anterior part of septum Middle and inferior conchae Lateral nasal wall Skin and cartilaginous end of the nose
Lacrimal			Lacrimal gland Conjunctiva and skin of upper lid temporally
	Anastomosis with the zygomatico-temporal branch of the zygomatic		Skin of the forepart of forehead up to the lateral side of orbit Skin of cheek

Maxillary Nerve or Second Division of the Trigeminal

Branches		Sensory Supply
Recurrent or middle meningeal		Dura mater
Zygomatic	Temporal—communicates with the lacrimal	Skin of forepart of forehead up to lateral side of orbit
	Malar	Skin of cheek
Sphenopalatine		Palate and nasal cavity Periorbita Involuntary orbitalis muscle Sphenoidal sinus Posterior ethmoidal cells Minute fibers to: Lacrimal gland, Sixth nerve, Ciliary ganglion, Optic sheath
Posterior superior alveolar		Molar teeth Gums Mucous membrane of maxillary sinus
Middle superior dental		Two premolar teeth
Anterior superior dental		Lower part of lacrimal sac and nasal duct Mucous membrane of nasal cavity Incisor and canine teeth
Infra-orbital	Inferior palpebral	Skin and conjunctiva of lower lid
	External nasal	Skin of the side of the nose
	Superior labial	Skin of cheek Mucous membrane and skin of upper lip

Block of the Infra-orbital Nerve

Blocking of the infra-orbital nerve may be accomplished by injecting the infra-orbital foramen or the inferior orbital fissure (sphenomaxillary foramen). Either may be very easily injected. The advantage of injecting the inferior orbital fissure is that the zygomatic nerve is likewise blocked. Also, by withdrawing the needle about 2 cm. and redirecting it upward and inward toward the apex of the orbit, the muscular cone can be injected. In this way, by piercing the skin only twice, complete anesthesia of the orbital contents is obtained.

Technique.—A wheal is raised at the inferior temporal margin of the orbit, just as for the injection within the muscular cone.

The No. 2 needle is introduced through the wheal and the point is directed downward and temporally at an angle of about 45 degrees until the bony floor of the orbit is felt. The point of the needle is kept in close contact with the bone. When the needle has been advanced from 1.5 to 2.5 cm., the bone will no longer be felt, because the needle will have reached the inferior orbital fissure. The syringe is then lowered, thus raising the point of the needle, but keeping it in the same plane. The needle is then advanced another centimeter, and 2 or 3 c.c. of procain solution are injected. The needle is withdrawn 1 or 2 cm. until it is out of the fissure, and then is directed upward and inward toward the apex of the orbit. The patient should be directed to look upward and inward, the needle should be introduced into the muscular cone, and 2 or 3 c.c. of procain solution should be injected. By these last two injections the infra-orbital, the zygomatic branch of the superior maxillary, and the nerves within the muscular cone are blocked. These injections, with the injection of the frontal and lacrimal nerves, complete the anesthesia of the orbital contents.

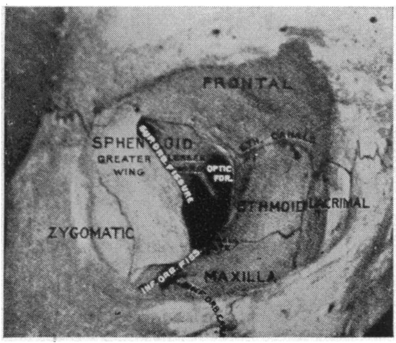

Fig. 10.—Orbit showing the location of the fissures and foramen (Whitnall).

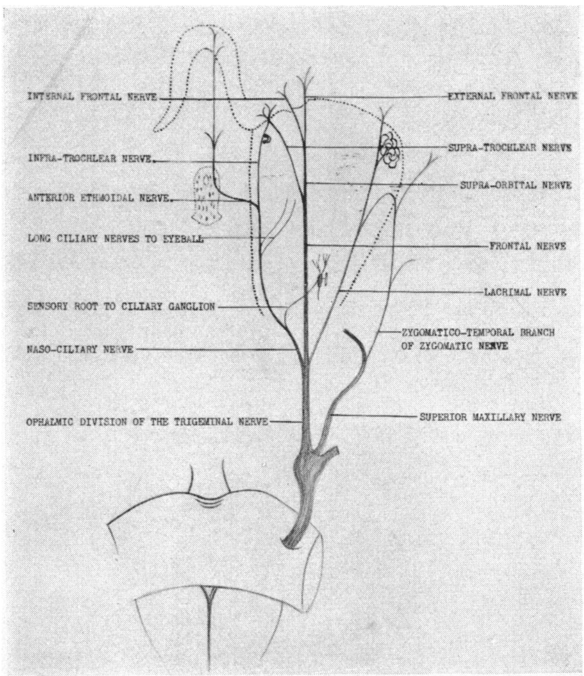

Fig. 11.—Diagram showing the distribution of the ophthalmic division of the trigeminal nerve (after Whitnall).

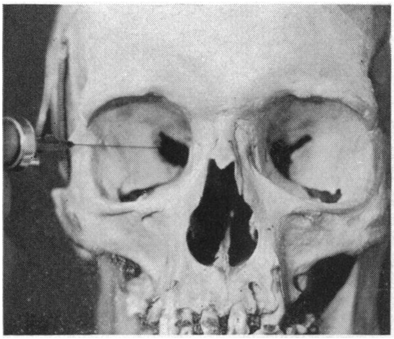

Fig. 12.—Skull showing the needle in position to inject the superior orbital fissure and block the frontal and lacrimal nerves.

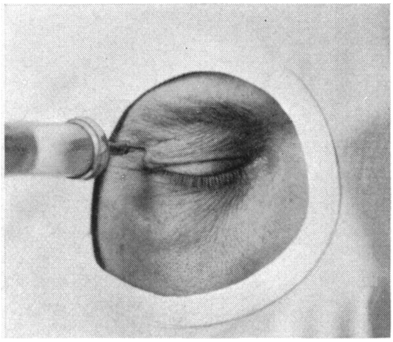

Fig. 13.—Block of the frontal and lacrimal nerves.

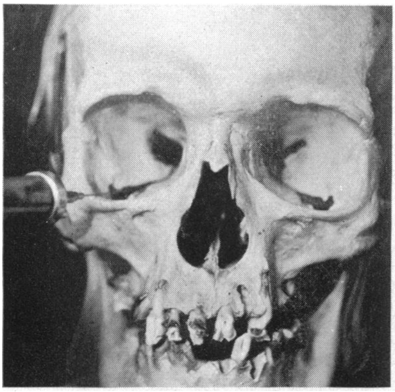

Fig. 14.—Skull showing the needle in the inferior orbital fissure for block of the infra-orbital, zygomatic, and anterior superior dental nerves.

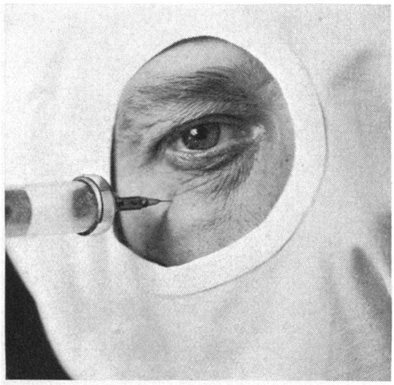

Fig. 15.—Injecting the inferior orbital fissure for block of the infra-orbital, zygomatic, and anterior superior dental nerves.

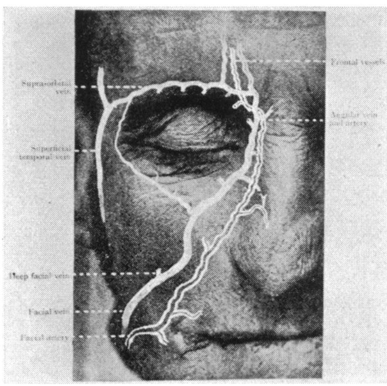

Fig. 16.—Illustration from Whitnall, showing the approximate positions of the main vessels of the face which should be avoided, particularly in blocking the infratrochlear nerve.

Operation upon the Lacrimal Sac

Anesthesia for operations upon the lacrimal sac is obtained by blocking the external nasal or infratrochlear and the infra-orbital nerves.

The infratrochlear nerve is the direct continuation in the orbit of the nasociliary or nasal nerve after the larger branch leaves the orbit by passing through the anterior ethmoidal foramen (fig. 11). The infratrochlear nerve lies close to the superior nasal wall of the orbit. It runs beneath the superior oblique muscle and the trochlea, and at this point there is a communicating branch to the supratrochlear nerve. Before piercing the septum orbitale, the infratrochlear nerve divides into several branches to supply the skin and the conjunctiva of the lids near the internal canthus, the canaliculi, the caruncle, the lacrimal sac, and the root of the nose.

Block of the Infratrochlear Nerve

A wheal is raised at the superior nasal angle of the orbit. A 3.5 cm. needle is then introduced through the wheal just a little above and to the nasal side of the trochlea. It should be kept close to the superior nasal wall, and a small quantity of procain solution should be injected as the needle advances. At a depth of about 3 cm., 2 or 3 c.c. of a 2 per cent. solution of procain with epinephrin is injected. Occasionally the angular vein is pierced, but if care is taken not to inject while the needle is in the lumen, no harm will be done, although the resulting ecchymosis is annoying.

Block of the Infra-orbital Nerve

The infra-orbital foramen is located about 0.5 to 1 cm. below the inferior orbital margin, about 2.5 cm. from the midline of the face, and in line with the supra-orbital notch. Just below the center of the inferior orbital margin a depression can usually be felt in which the foramen is located.

The infra-orbital canal is from 1 to 1.5 cm. in length, and the angle varies considerably in different skulls. There is a grooved depression leading up to the foramen, which aids considerably in finding it. After entering the foramen the angle of the needle can be changed to correspond to the angle of the canal, and the needle can then be introduced easily with practically no resistance.

A wheal is raised about 1 cm. from the middle of the ala of the nose. The same needle is introduced through the wheal almost to the bone, and is then directed upward and temporally at an angle of about 20 degrees (figs. 19 and 20). As the needle advances the procain solution is injected. The needle point is kept in contact with the bone until the foramen is felt; it is then introduced from 0.5 to 1 cm. along the infra-orbital canal and 1 c.c. of procain solution is injected.

Labat[40] suggests placing the left index finger over the foramen, indicating its location and the axis of the infra-orbital canal. This makes it easier to find the foramen with the needle. This injection produces anesthesia of the conjunctiva and the skin of the lower lid, the skin of the cheek, the skin of the side of the nose, the skin and the mucous membrane of the upper lip, the lower part of the lacrimal sac, the nasal duct, and the incisor and canine teeth.

Field Block for Anesthesia of the Lids

Since there is so much overlapping and variation in the sensory nerve supply of the lids, it is simpler, for operations involving a considerable area of the lids, to produce a field block rather than to try to block the individual nerves.

Procedure.—A wheal is raised at the center of the orbital margin, above or below, depending upon which lid is to be blocked, and the 3.5 cm. needle is introduced through the wheal. The point of the needle should follow the orbital margin closely, but should not penetrate the orbital septum. A 2 per cent. solution of procain with epinephrin is used, and is injected slowly as the needle advances. In order to inject all along the margin and to infiltrate well around the nerves

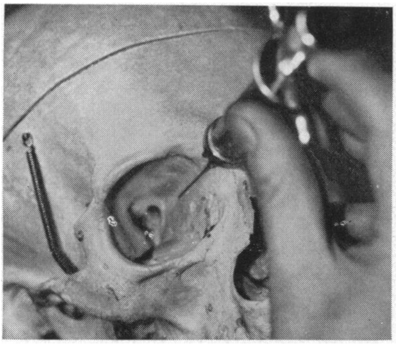

Fig. 17.—Skull showing needle in position to block the infratrochlear nerve.

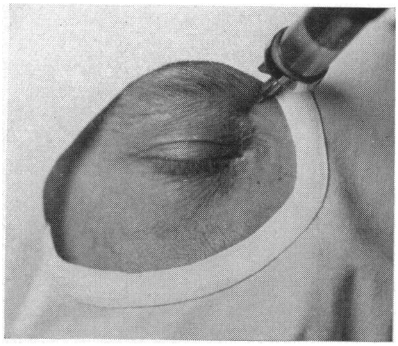

Fig. 18.—Block of the infratrochlear nerve.

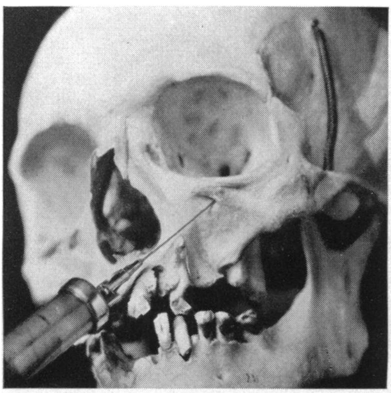

Fig. 19.—Skull showing the needle in position to inject the infra-orbital canal in order to block the infra-orbital and anterior superior dental nerves. (A 3.5 cm. needle was used in this picture better to show the angle, but for the injection the 2 cm. wheal needle is used.)

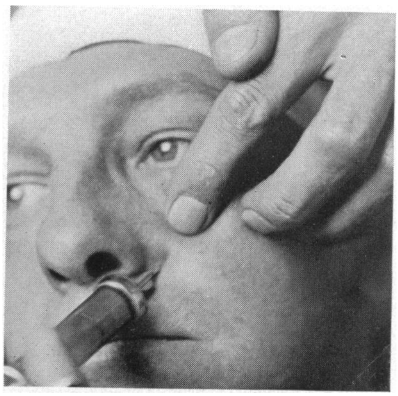

Fig. 20.—Injection of the infra-orbital canal to block the infra-orbital and anterior superior dental nerves.

that emerge from the orbit, it is necessary to withdraw the needle a little and redirect it several times. The injection should not be made just under the skin, but close to the periosteum. About 0.5 c.c. of the anesthetic solution should be injected quite deeply in the vicinity of the supra-orbital notch.

After injecting one half of the superior or inferior orbital margin, depending upon which lid is being blocked, the needle is partially withdrawn, it is redirected, and the other half of the orbital margin is injected.

For removal of small tumors of the lids, such as chalazia and papillomas, infiltration at the site of the tumor is usually sufficient and is the simplest method. It also decreases the bleeding. For operations involving the lid margin, which, due to its rich nerve supply, is extremely sensitive, it is particularly important that the lid margin be well infiltrated. This is also necessary to avoid causing pain in removing chalazia, as emphasized by O'Brien.[41]

In operations in which large conjunctival flaps are raised instillation anesthesia is often not sufficient and pain may be experienced, particularly when the flap is sutured. This may be due to the fact that the deeper layers of the conjunctiva or subconjunctival tissue are not completely anesthetized, or because of the rapid escape of the tissue fluids when the flap is raised, which favors the more rapid return of sensibility. This is also true in operations for pterygii. By the use of subconjunctival injections in such operations unnecessary pain is avoided.

AKINESIA

The desirability of producing temporary paralysis of the orbicularis muscle by blocking the temporofacial division of the facial nerve, for intra-ocular operations, particularly cataract extractions, is so generally conceded that comment seems to be unnecessary. Of the various modifications of the van Lint method, the simplest and most satisfactory procedure is the one proposed by O'Brien.[42] His description is as follows: "The point of the injection is just anterior to the tragus of the ear, below the posterior portion of the zygomatic process and directly over the condyloid process of the mandible. Going straight inward with a sharp needle, one strikes the bony condyloid process at a depth of about 1 cm. As soon as this bone is felt with the needle, I begin injecting 2 per cent. solution of procain hydrochlorid, and gradually withdrawing, inject about 2 c.c. of solution. Lid paralysis begins to appear usually in from thirty to sixty seconds, and, after a very few minutes, is so marked that the patient is unable to close the lids, and the palpebral fissure is widely opened."

The course of the branches of the seventh nerve which supply the orbicularis muscle often varies considerably, so that paralysis is not always secured with the first injection. If, after several minutes, the action of the muscle has not been affected, another injection should be given. The point of injection should be changed slightly, having in mind the more common variations in the course of the nerve. The object of the injection should be accomplished before proceeding with the operation.

A wheal should be raised before introducing the needle, and the needle should be introduced gently, so that the periosteum of the condyloid process is not pricked, as this causes quite sharp pain. The method of locating the condyloid process is simplified by having the patient open his mouth and thrust the jaw forward.

In selecting the method of anesthesia for any operation, the age and temperament of the patient must be considered. By the use of instillation anesthesia only, many operations upon the eye may be successfully performed with no apparent discomfort in a somewhat large proportion of patients. Because of this the surgeon often does not make use of the procedures that produce more complete anesthesia, regarding them as unnecessary and superfluous. There is, however, a

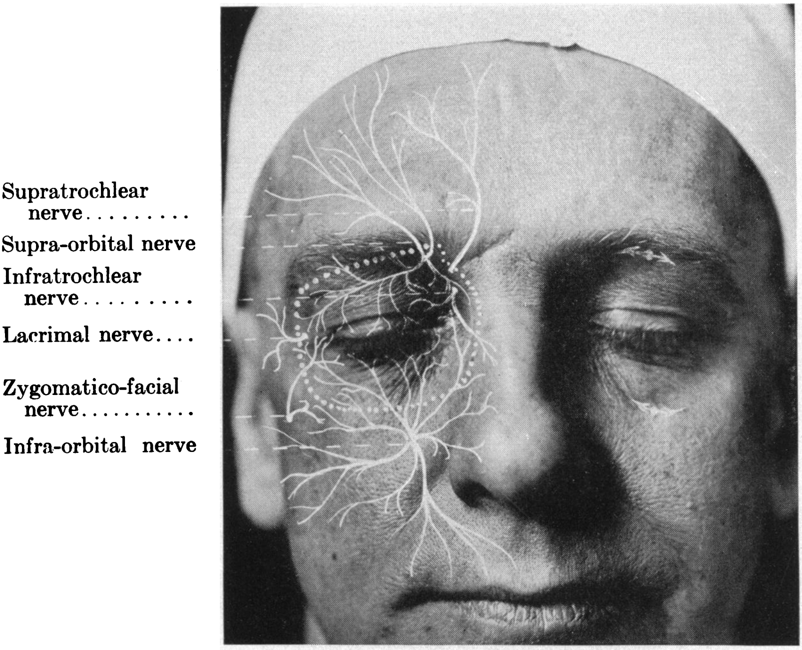

Fig. 21.—The solid lines indicate the sensory nerve supply, and the dotted line, the orbital margin (from Whitnall, modified)

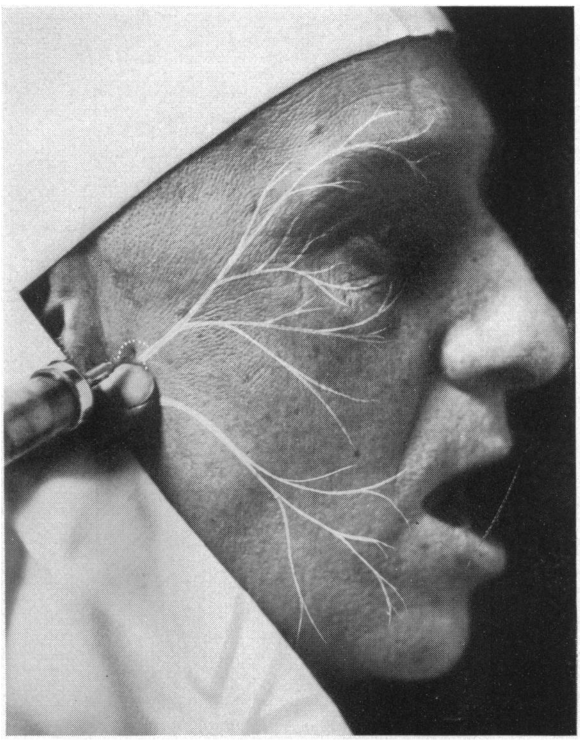

Fig. 22.—Blocking of the temporofacial division of the facial nerve to produce temporary paralysis of the orbicularis muscle.

small percentage of patients who are either not sufficiently anesthetized by instillation anesthesia or are less stoical than others. These are the patients who so often squeeze and damage their eyes seriously, or, by their inability to hold their eye quiet, make the operation more difficult. Since it is not possible before operation to select the patients who will not squeeze or hold well, it seems to be wiser to err on the side of always obtaining complete anesthesia before beginning the operation.

For all operations upon the globe where a forcible contraction of the orbicularis would injure the eye this muscle should be temporarily paralyzed. Since this can be done so easily one seems to be hardly justified in taking the chance of having an eye injured in this way by not obtaining paralysis of the orbicularis before beginning the operation.

The careful use of sedatives before operation will assist greatly in producing a quiet, tranquil patient. The various sedatives act differently in different persons. In some they increase the excitability and may cause nausea and vomiting, so that it does not seem advisable to use any sedatives, particularly in globe operations, without ascertaining previously their action on that particular patient. Usually patients are admitted to the hospital at least one day before the operation. On the first night in the hospital a sedative can be given; this not only allows the operator to learn the action of the drug on that particular patient, but also whether the drug acts in the usual manner; besides, it gives the patient a quiet, restful sleep which is excellent preliminary preparation for the operation. If there is no undesirable reaction, it is usually quite safe to use the drug again before the patient goes to the operating room. Often patients, especially the older ones, are accustomed to taking some particular sedative; it is usually well to use the one they are accustomed to.

Some of the barbituric acid group of sedatives, such as phenobarbital, sodium amytal, nembutal, etc., have a very satisfactory action and rarely cause nausea or other undesirable reactions. These drugs have the effect of quieting and calming the patient, which adds greatly to the ease of the operation. Also, they have the added value of counteracting, to some extent, the toxic action of the anesthetic agent.

The dose varies somewhat in different patients. As a test dose, phenobarbital, 1½ grains, may be used before retiring. Then, if satisfactory, a dose of from 1½ to 3 grains may be given an hour before the operation.

In the following paragraphs an attempt has been made to group the different operations upon the eye and arrange them in alphabetical order, indicating briefly for each operation a method of producing complete anesthesia, which has previously been described in detail.

Ablation of Staphyloma.—Sharp pain usually accompanies the sudden decrease of intra-ocular tension, which often precipitates a forcible contraction of the orbicularis muscle, so that complete anesthesia is desirable.

1. Instillation anesthesia (p. 416)
2. Retrobulbar injection within the muscular cone (p. 424)
3. Akinesia (p. 439)
4. Subconjunctival injection, if the eye is inflamed (p. 423)

Abscission of Prolapsed Iris.—

1. Instillation anesthesia (p. 416)
2. Akinesia (p. 439)
3. Subconjunctival injection, as the eye is usually inflamed (p. 423)

This is usually sufficient, but if the eye is quite inflamed and painful and the wound is not large, a retrobulbar injection should also be used, so that when traction is made upon the iris, no pain will be experienced. The operation can then be completed leisurely and carefully without danger to the eye.

Blepharoplasty.—The method of anesthesia used will depend upon the extent of the involvement and the individual features of the particular case. By means of infiltration anesthesia and field or nerve block, even quite extensive plastic operations may be performed satisfactorily.

Canaliculus, Slitting of.—

1. Instillation anesthesia (p. 416)
2. Infiltration just below the canaliculus

Canthotomy.—

1. Instillation anesthesia (p. 416)
2. Intradermal wheal at the external canthus (p. 421)
3. Infiltration of the subcutaneous tissue and deeper tissues between the external canthus and the orbital margin

Canthoplasty.—The same anesthesia as for canthotomy is indicated; only the lids are infiltrated as far as the operation is to extend. If the infiltration is followed by pressure and massage, there will be but little distortion of the operative field.

Lid block (p. 438) may be used and thus avoid infiltrating the operative field, but it is rarely necessary.

Capsulotomy or Discission.—For discission of congential or juvenile cataracts, instillation anesthesia is usually sufficient. In secondary or membranous cataracts, in which the capsule is thick and tough, instillation anesthesia is not sufficient. To avoid the pain caused by the traction on the ciliary processes subconjunctival injections near the cornea nasally and temporally should be given. Frequently patients who have had a discission with instillation anesthesia remark that they did not feel the extraction but that the needling was very painful.

Cataract Extraction.—

1. Instillation anesthesia (p. 416)
2. Akinesia (p. 439)
3. Retrobulbar injection within the muscular cone (p. 424)

In dislocated cataracts in which the eye is inflamed and painful, a subconjunctival injection should also be given to avoid pain when the fixation forceps is used.

If the type of extraction to be done is not satisfactory with a lowered tension, the operation should be performed directly after the retrobulbar injection is given, as recommended by Elschnig. A subconjunctival instead of the retrobulbar injection may be used, although the anesthesia is not complete.

Cauterization of the Cornea (Ulcers, Keratoconus).—Instillation anesthesia is usually sufficient except in an operation in which the cornea is to be perforated; in the latter case a retrobulbar injection should be given to prevent the sharp pain incident to the sudden evacuation of the anterior chamber.

If the eye is inflamed, as with a corneal ulcer, a subconjunctival injection should be given to avoid pain when the fixation forceps is used.

Chalazion.—

1. Instillation anesthesia (p. 416)
2. Infiltration around the chalazion and deeply along the lid margin (p. 423)

Coloboma and Injuries of the Lids.—

1. Instillation anesthesia (p. 416)
2. Lid block (p. 438) or infiltration around the area involved

Dacryocystitis, Acute, Incision of.—The procedure is less painful if ethyl chlorid is sprayed on a cotton applicator and applied to the site of the incision.

On account of the marked induration and swelling, infiltration anesthesia or nerve block is often not advisable.

Detachment of the Retina (Microdiathermic Punctures—Ignipuncture).—

1. Instillation anesthesia (p. 416)
2. Retrobulbar injection within the muscular cone (p. 424)

Ectropion—Entropion.—The anesthesia differs according to the type of operation to be performed.

For cauterization, instillation and infiltration anesthesia are sufficient. For the more extensive plastic operations involving the lid, infiltration anesthesia (p. 423) or block of the lid (p. 438) is necessary.

Enucleation and Evisceration.—

1. Instillation anesthesia (p. 416)
2. Retrobulbar injection within the muscular cone (p. 424)
3. Subconjunctival injection, if the eye is inflamed and painful (p. 423)

Epicanthus.—Infiltration anesthesia if followed by pressure is quite satisfactory.

With some very young children a general anesthetic is often necessary.

Exenteration.—While general anesthesia is usually preferred, still satisfactory anesthesia can be produced by blocking the frontal, lacrimal, and infra-orbital nerves (pp. 433 and 436), and a retrobulbar injection within the muscular cone (p. 424)

Extirpation of Lacrimal Gland.—

1. Intradermal wheal at the superior temporal margin of the orbit (p. 421)
2. Infiltration along the superior temporal margin of the orbit (p. 423)
3. Instillation anesthesia, also, if the gland is to be removed by the conjunctival route

Extirpation of Lacrimal Sac.—Block of the infratrochlear and the infra-orbital nerves (p. 437) produces complete anesthesia without any disturbance of the anatomy around the sac.

By the infiltration method the sac can be removed without causing pain, but if the nasal duct is to be curetted, pain is experienced. By using pressure and massage after infiltrating the tissue over the sac, around the top of the sac, and the region about the entrance of the naso-lacrimal duct, the anatomy and landmarks are disturbed very little.

Foreign Body of Cornea, Removal of.—

1. Instillation anesthesia (p. 416)

One instillation is often sufficient, but a few extra drops require very little additional time and add greatly to the comfort of the patient and the ease of removal, and in the end frequently save time and epithelium.

Foreign Body of Globe, Removal of.—

1. Instillation anesthesia (p. 416)
2. Akinesia (p. 439)
3. Retrobulbar injection within the muscular cone (p. 424)
4. Subconjunctival injection, if the eye is red and inflamed (p. 423)

When foreign bodies are removed through a scleral incision, a retrobulbar injection has the added advantage of making the eye soft so that the danger of vitreous presenting is lessened.

Glaucoma Operations (Cyclodialysis, Iridectomy, Iridotasis, Lagrange, Sclerotomy).—

1. Instillation anesthesia (p. 416)
2. Akinesia (p. 439)
3. Retrobulbar injection within the muscular cone (p. 424)
4. Subconjunctival injection (p. 423) in cases in which the eye is inflamed and painful, as in acute glaucoma, otherwise the use of the fixation forceps causes pain.

By the use of the retrobulbar injection the pain incident to a sudden decrease of tension is avoided. Also a postoperative rise of tension due to edema of the ciliary processes or the so-called quiet iritis is less likely to occur.

In some of the foregoing operations akinesia may be superfluous, but hard squeezing of the eye after the incision might easily cause considerable damage, and the akinesia does no harm and requires only a few minutes.

For the corneo-scleral trephine operation, a ½ per cent. solution of pantocain, a 2 per cent. solution of butyn, or an anesthetic agent that does not dilate the pupil is instilled. Epinephrin is not used until just before the operation is to be begun.

Subconjunctival injections of a 2 per cent. solution of procain are given at the nasal and the temporal side of the cornea, because if given above, it is not usually possible to obtain as thick a conjunctival flap. The injection tends to separate the conjunctiva from the subconjunctival tissue and Tenon's capsule, which is more firmly adherent to the sclera. If the injection is not given above, the conjunctiva with the subconjunctival tissue and Tenon's capsule can be dissected cleanly and quite easily from the sclera, giving a thicker flap.

As a rule, a retrobulbar injection is not used for the trephine operation, lest the tension might be lowered to such an extent that the iris will not prolapse well. However, retrobulbar injection of procain and epinephrin given in glaucomatous eyes does not seem to lower the tension as it does in nonglaucomatous eyes.

Akinesia is advisable, as a squeeze after the aqueous escapes may injure the lens or cause a prolapse of the ciliary processes.

Hordeolum, Incision of.—Although this is a very simple procedure, it is also extremely painful. A cotton applicator saturated with ethyl chlorid and applied to the site of the incision render the operation less painful. If there is not too much swelling and induration, often the lid around the hordeolum can be infiltrated so that little pain is experienced, or in some cases a nerve or lid block is most satisfactory (p. 438)

Iridectomy—Iridotomy.—

1. Instillation anesthesia (p. 416)
2. Akinesia (p. 439)
3. Retrobulbar injection within the muscular cone (p. 424)
4. Subconjunctival injection, if the eye is inflamed and painful (p. 423)

In some iridotomies in which a very small incision is made in the cornea, as for iris bombé, akinesia is not necessary.

Keratoplasty.—

1. Instillation anesthesia (p. 416)
2. Akinesia (p. 439)

3. Retrobulbar injection within the muscular cone (p. 424)

As cocain somewhat devitalizes the cornea, it may account for some of the grafts becoming cloudy. For this operation other anesthetic agents seem to be advisable.

Krönlein Operation.—While this operation is usually performed under general anesthesia, it may also be done under local anesthesia just as many intracranial operations are done.

The type of anesthesia to be used depends to a great extent upon the orbital involvement. With large orbital tumors, particularly vascular tumors, an orbital block is not advisable. With small tumors, or when the operation is done to relieve exophthalmos, it may be accomplished with a field block surrounding the area of operation. After the bone flap has been raised, intra-orbital injections can be used as necessary, depending upon the amount of orbital interference.

Muscle Operations (Advancement, Cinch or Tucking Operations, Recession, Resection).—

1. Instillation anesthesia (p. 416)
2. Retrobulbar injection within the muscular cone (p. 424)

The paresis of the muscles caused by the retrobulbar injection is an objection, but not so much so as with general anesthesia. However, before the operation, the surgeon has usually estimated the amount of correction necessary and has decided on just how much he will advance, resect, or recede the muscle, so that the paresis is not a very serious objection. A deep injection along the muscle may be used, but it does not prevent the pain caused by traction on other muscles, and frequently the injection balloons the surrounding tissues, making the operation more difficult to perform. Also the retrobulbar injection is as easy and safe as a deep injection along the muscle.

Tenotomy of the recti can be performed satisfactorily with instillation anesthesia, but usually it causes considerable pain, which can be avoided with either a retrobulbar injection or an injection in the vicinity of the muscle to be tenotomized; if massaged with pressure, the anatomy is disturbed very little by the injection.

Tenotomy of the Inferior Oblique.—

1. A wheal is raised in the vicinity of the inferior nasal margin of the orbit (p. 421)
2. Infiltration beneath the skin and of the deeper tissues along the orbital margin in the vicinity of the attachment of the inferior oblique (p. 423)

If the tenotomy is to be done through the conjunctiva, instillation anesthesia should be used, and the injection along the orbital margin may be made through the conjunctiva of the lower culdesac.

Opticociliary Neurotomy.—

1. Instillation anesthesia (p. 416)
2. Retrobulbar injection within the muscular cone (p. 424)
3. Subconjunctival injection, since the eye is usually inflamed and painful (p. 423)

Paracentesis of the Cornea and Sclera.—The eye is usually inflamed, and although this is a very simple operation, it is generally extremely painful unless complete anesthesia is obtained.

1. Instillation anesthesia (p. 416)
2. Retrobulbar injection within the muscular cone (p. 424)
3. Subconjunctival injection if the eye is inflamed, otherwise the use of the fixation forceps is quite painful (p. 423)
4. In some cases akinesia is advisable (p. 439)

Plastic Operations.—Since plastic operations vary so markedly with each individual case, it is not practical to attempt to outline a definite anesthetic procedure. While some extensive plastic operations require general anesthesia, many can be performed with local anesthesia by means of infiltration, nerve block, and field block (p. 422). Scar tissue cannot be satisfactorily infiltrated, but unless it is quite extensive, the tissue can usually be rendered anesthetic by the use of field or nerve block.

Probing of Lacrimal Duct.—Instillation anesthesia and the injection of several drops of a 3 per cent. solution of cocain into the lacrimal sac somewhat relieve the pain, but a block of the infratrochlear and the anterior superior dental nerves (p. 437) renders the procedure practically painless. For passing small probes, in which very little pressure is exerted, instillation in the conjunctival and lacrimal sacs is usually sufficient, but one probing with large probes, if adequate anesthesia is not used, will probably be the last.

Pterygium.—

1. Instillation anesthesia (p. 416)
2. Subconjunctival injection under the pterygium and below if it is to be transplanted below

Ptosis.—The operations for ptosis are somewhat numerous, but the majority of them can be performed under local anesthesia, particularly if the patient is not too young.

Here again the procedure depends upon the operation that is to be used. For operations that involve the superior rectus, as the Motais operation, the following procedures are adequate:

1. Instillation anesthesia (p. 416)
2. Retrobulbar injection within the muscular cone (p. 424)
3. Subconjunctival injection in the upper culdesac (p. 423)
4. Infiltration under the skin of the lid, where the sutures pass through the skin (p. 423)

Saemisch Keratomy.—

1. Instillation anesthesia (p. 416)
2. Retrobulbar injection within the muscular cone (p. 424)
3. Subconjunctival injection to avoid pain on using the fixation forceps (p. 423)

Tattooing.—

1. Instillation anesthesia (p. 416)

Trachoma—(*a*) *Expression.*—

1. Instillation anesthesia (p. 416)
2. Large subconjunctival injection in the culdesac (p. 423)

In young children and in some adults a general anesthetic is usually necessary, as the operation is extremely painful.

(*b*) *Combined Excision of the Fornix and Tarsus.*—

1. Instillation anesthesia (p. 416)
2. Large subconjunctival injection in the culdesac (p. 423)

CONCLUSION

Practically all ophthalmic operations may be painlessly and safely performed under local anesthesia provided the anesthetic is carefully and properly administered.

REFERENCES

1. Gaedcke: Arch. d. Pharm., 1855, cxxi, p. 141.
2. Koller: Ber. über d. ophth. Gesellsch., Heidelberg, 1884, xvi, p. 60.
3. Braun: Local Anesthesia, 1924, p. 71.
4. Niemann: Inaugural Dissertation, Göttingen, 1860.
5. Scherzer: Über die peruanische Coca, Stuttgart, 1860.
6. von Anrep: Arch. f. d. ges. Physiol., 1880, xxi, p. 38.
7. Coupard and Bordereau: Seances et mémoires Soc. de biol., 1884, Serie 8, p. 1.
8. Darwin, Francis: Eugenics Review, 1914.
9. Knapp: Arch. Ophth., 1884, xiii, p. 402.
10. Siegrist: Klin. Monatsbl. f. Augenh., 1907, xlv, p. 106.
11. Löwenstein: Klin. Monatsbl. f. Augenh., 1908, xlvi, p. 592.
12. Seidel: Klin. Monatsbl. f. Augenh., 1911, xlix, p. 329.
13. Hall and Halsted: New York M. J., December 6, 1884, p. 643.
14. Einhorn: München. med. Wchnschr., 1899, xlvi, p. 1218.
15. Takamine: Therap. Gaz., xvii, p. 221.
16. Shaw: New York State J. Med., 1884, xl, p. 588.
17. Braun: Local Anesthesia, 1924, p. 29.
18. Braun: Ibid., p. 93.
19. Braun: Ibid., p. 184.
20. Labat: Regional Anesthesia, 1928, p. 39.
21. Sollman: J. A. M. A., January 26, 1918, p. 216.
22. Wilmer and Paton: Tr. Am. Ophth. Soc., 1932, xxx, p. 31.
23. Schmidt: Chirurg., 1931, iii, p. 97.
24. Lundy and Essex: Proc. Staff Meeting, Mayo Clinic, 1931, vi, p. 376.
25. Singer: Wien. med. Wchnschr., 1931, lxxxi, p. 1593.
26. Kies: Zentralbl. f. Chir., 1930, lvii, p. 3090.
27. Schülein: München. med. Wchnschr., 1931, lxxvii, p. 1475.
28. Braun: Local Anesthesia, 1924, p. 117.
29. Labat: Regional Anesthesia, 1928, p. 40.
30. Braun: Local Anesthesia, 1924, p. 119.
31. Labat: Regional Anesthesia, 1928, p. 41.
32. Labat: Ibid., p. 45.
33. Labat: Ibid., p. 44.
34. Labat: Ibid., p. 1.
35. Whitnall: Anatomy of the Human Orbit, 1921, p. 290, Fig. 151.
36. Whitnall: Ibid., p. 297.
37. Duke-Elder: Brit. J. Ophth., Monograph, 1927, Supplement 3.
38. Friedenwald: Am. J. Ophth., 1932, xv, p. 191.
39. Duverger: L'Anesthesie Locale en Ophtalmologie.
40. Labat: Regional Anesthesia, 1928, p. 117.
41. O'Brien: Tr. Sect. Ophth., A. M. A., 1927, p. 252.
42. O'Brien: Ibid., p. 250.